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The invention relates to acquisition methods by means of an X-ray radiography device designed, in particular, for angiography.

In vascular imaging, in many cases, it is important to be able to identify the actual size of arteries from pictures coming from the X-ray radiography device. This is because stenosis, a narrowing of the artery, is frequently treated by introducing a balloon into the artery then by dilating it to the size of the healthy artery. The size of the healthy artery is determined by measuring the artery on each side of the lesion due to the stenosis. This measurement is used in order to select a balloon of suitable size in order to treat the stenosis. The pictures coming from the X-ray radiographs are projections and, consequently, a magnification factor must be determined in order to deduce therefrom the actual size of the artery from its size on the picture. Several approaches have been proposed in order to calculate the magnification factor. One approach currently used is to locate a catheter or any other object whose size is known in the image and to determine its size on the picture. The surgeon enters the actual size of the object into the system. Thus, the magnification factor for the object is determined. Assuming that the distance to the projection centre is similar for the object and for the artery, the same magnification factor is used to determine the size of the artery. This approach has two drawbacks:

- it requires the surgeon to provide information which is not directly connected with the pathology, that is to say the size of the instrument which he uses as a calibration object. Should there be an error, a poor measurement is made.

- the algorithm assumes that the calibration object and the artery to be measured are close to each other. This is almost never the case. Furthermore, in certain situations, when the surgeon wishes to employ a catheter as a calibration object, the catheter is not necessarily visible on the image selected in order to measure the artery. This may lead to considerable errors of accuracy in determining the size of the artery, which is detrimental to the proper treatment of the stenosis.

One aim of the invention is to provide a method for determining the magnification factor which is simple and accurate during use.

For this, according to the invention, a method of determining a magnification factor in a radiography device of the type comprising an X-ray source and recording means placed facing the said source is provided, the said source and the said recording means being mounted so as to rotate about at least one axis with respect to a support on which an object to be X-rayed is intended to be positioned, the method comprising the steps of:

- acquiring at least two images corresponding to two different angular positions of the source and of the recording means with respect to the support;
- identifying on these images projections of at least one point of the X-rayed object; and
- determining the magnification factor of at least one of the images, first, as a function of the angular displacement of the source and of the recording means between the acquisitions of the images in question and, secondly, as a function of the positions on these images of the identified projections.

Thus, it is no longer necessary for the surgeon to enter the size of a known object. The position of the artery is perfectly determined in the field of the radiography device by means of triangulation given the displacement angle and the position of the projections. Knowledge of this position makes it possible to determine the distance from the artery to the X-ray source. Knowing the distance from the image to the X-ray source of the radiography device as a result of its construction, it is easy for the magnification factor of this image to be accurately determined.

Advantageously, the method has at least one of the following characteristics:

- at least two images on which an identification is carried out for the purpose of determining a magnification factor are acquired for angular positions separated by an angle greater than 15°;
- at least two images on which an identification is carried out for the purpose of determining a magnification factor are acquired for angular positions separated by an angle greater than 20°;
- during an acquisition step, a plurality of images is acquired between a first and a second angular position;
- identification of the projections implements automatic tracking of at least one point of the object from one image to another, on the plurality of images acquired;
- the automatic tracking implements monitoring by means of a similarity criterion of at least one region of the object;
- the similarity criterion is a correlation criterion;
- the automatic tracking implements monitoring of at least one segment that is identified on the images.

Also, according to the invention, an X-ray radiography device, comprising an X-ray source and recording means placed facing the said source, is provided, the said source and the said recording means being mounted so as to rotate about at least one axis with respect to a support on which an object to be X-rayed is intended to be positioned, the device comprising means capable of processing the images acquired by implementing the method having at least one of the previous characteristics.

Also, according to the invention, a method of acquiring vascular radiographic images by means of a radiography device of the type comprising an X-ray source and recording means placed facing the said source is provided, the said source and the said recording means being mounted so as to rotate about at least one axis with respect to a support on which an object to be X-rayed is intended to be positioned, a method where a magnification factor is determined by implementing a method having at least one of the previous characteristics.

Other characteristics and advantages of the invention will become apparent during the following description of a preferred embodiment. In the appended drawings:

- Figure 1 presents a schematic view of the radiography device implementing the method according to the invention; and
- Figure 2 is an outline diagram showing the taking of two images from two different angles during the method according to the invention.

With reference to Figure 1, the X-ray radiography device 1 comprises means for taking radiography pictures 2 and means for emitting X-rays 3 in the form of an X-ray source. The means for taking radiographic pictures 2 are, in this case, a digital camera. The X-ray source 3 and the digital camera 2 are attached to

each end of a carrying arm 7, in this case in the form of a semicircle. The semicircular arm 7 is connected by sliding to a second arm 8. The second arm 8 is itself connected by sliding and by rotation to the stand 9 of the radiography device 1.

The arm 8 is mainly capable of carrying out rotational movements 6 about its own axis. As for the semicircular arm 7, this is capable of sliding with respect to the arm 8, so that the semicircular arm 7 makes a rotational movement 5 with respect to the centre of the semicircle forming the arm 7.

In use, the body of the patient is positioned between the X-ray source 3 and the digital camera 2, so that the artery 4 to be X-rayed is in the field 10 of the apparatus. This artery 4 is then at a distance z from the X-ray source 3. By construction, the digital camera 2 is at a distance Z from this same X-ray source 3. The image of the artery 4 on the picture taken by the digital camera 2 is a projection whose magnification factor f is equal to the ratio Z/z.

In order to be able to calculate the magnification factor f, the X-ray radiography device 1 must determine the distance z, given that it knows the distance Z because of its construction. For this purpose, with reference to Figure 2, the radiography device 1 takes a first image I_1 while the source 3 is in position X_1 in order to take a picture at an angle α_1 with respect to a reference R. The artery 4 is identified on the image I_1 by its projection 4′. Next, the X-ray radiography device 1 will take a second image I_2 at a second acquisition angle α_2 with respect to the reference R, the X-ray source 3 then being in position X_2. Again, the artery 4 is identified on the image I_2 by its projection 4″. Given the successive positions of the X-ray source 3 at X_1 and at X_2, it is possible, by using triangulation calculation methods, to determine, on the

basis of projections 4′ and 4″ of the artery 4, the spatial position of a point P of the artery 4 in the field 10 of the radiography device 1.

The triangulation consists in determining the coordinates of a point P belonging to the artery 4. For this purpose, the projection P′ of the point P is identified on the image I_1. Given the coordinates for the position X_1 of the X-ray source 3, the equation of the straight line D_1 passing through X_1 and P′ is determined. Similarly, the projection P″ of the point P is identified on the image I_2. Given the coordinates for the position X_2 of the X-ray source 3, the equation of the straight line D_2 passing through X_2 and P″ is determined. The point P whose coordinates are sought is located in the middle of the segment of the common perpendicular of the straight lines D_1 and D_2, connecting the straight lines D_1 and D_2.

Given the spatial position of the point P of the artery 4, the radiography device 1 can easily calculate the distance z separating the artery 4 from the X-ray source 3, for any one of the images taken. And hence, it thereby determines the magnification factor of this image in question and thereby deduces the actual size of the artery in question.

In order to displace the X-ray source from the position X_1 to the position X_2, the semicircular arm 7 rotates about the artery 4, either in the direction of rotation 6, or in the direction of rotation 5. The direction of rotation is chosen by the surgeon according to the conditions of use of the radiography device 1 mainly within an operating theatre. During this rotation, the X-ray radiography device is capable of taking a series of successive images in a burst at an acquisition rate varying from 15 images per second to 30 images per second. The series of images is stored in a plurality of memories (not shown) of the radiography device 1.

Moreover, in order to carry out a proper triangulation to determine the spatial position of the artery 4, the separation $\Delta\alpha$ between the angles α_1 and α_2 is between 15° and 45°. Preferably, the separation $\Delta\alpha$ is equal to 20°. In order to rotate through an angle $\Delta\alpha$, the X-ray radiography device 1 displaces the source 3 along one of the aforementioned directions of rotation 5, 6 at a rate of between 30° per second and 40° per second. For example, the radiography device 1 is capable of taking a series of about 15 pictures for a separation $\Delta\alpha$ of 20°, at a speed of 40° per second, and for an image acquisition rate in a burst of 30 images per second. Over this series of pictures, each one comprising a different projection of the artery 4, the radiography device 1 will track the artery 4 by means of an image processing method which is implemented by a processor (not shown) of the radiography device 1 which has access to the plurality of memories having stored the series of images. This image processing method enabling tracking of this kind can be carried out in two ways:

- either the device determines a region around the artery 4 to be tracked and tracks this region throughout all the images constituting the series of images by optimizing a similarity criterion such as the correlation,
- or the device segments the artery over the first image and monitors this segmentation over the images constituting the series.

Such tracking methods are described in detail in the following articles:

- Zhaohua Ding & Morton H. Friedman *"Quantification of 3-D coronary arterial motion using clinical biplane cineangiograms"*, the International Journal of Cardiac Imaging, No. 16, pages 331 to 346, 2000.

- Deriche Rachid and Faugeras Olivier, *"Tracking line segment"*, Image and vision computing, Volume 8, No. 4, pages 261 to 271, November 1990.

The X-ray radiography device 1 implementing this method of acquiring and monitoring an artery is designed to be used mainly during surgical operations within an operating theatre. The surgeon positions the radiography device 1 around the patient, so that the artery 4 which he desires to study is in the field 10 of the radiography device 1. Since the CCD camera 2 and the X-ray source 3 are aligned at an angle α_1 with respect to the reference R, the surgeon takes a first picture on which he will indicate to the radiography device the artery 4 which he desires to study. Next, the radiography device 1 rotates the CCD camera 2 and the X-ray source 3, which are in alignment, up to an angle α_2 with respect to the reference R. During this rotation through an angle $\Delta\alpha$, the device takes a series of images in a burst, as has been described above. Over this series of images, the device tracks the designated artery 4, determines the spatial position of the artery 4 in the field 10 of the radiography device 1 by means of triangulation. It then determines the magnification factor f in order to be able to provide the surgeon with the actual size of the artery 4 which he would like to study, from the size determined from the projection of the artery 4 on at least one of the acquired pictures.

The device will then be able to determine the exact shape of the artery in the form of variations of the cross section over a given segment, from the series of pictures.